AN2500
Application note

ST10 electric motor control library: SPI drivers for MP49 power board

Introduction

STMicroelectronics provides a library of motor control functions that can be used as base blocks for motor control applications.

This application note describes the set of API to simplify the usage of the MP49 motor control power board. It provides ST10 compatible SPI drivers to configure the board and for diagnostic purposes.

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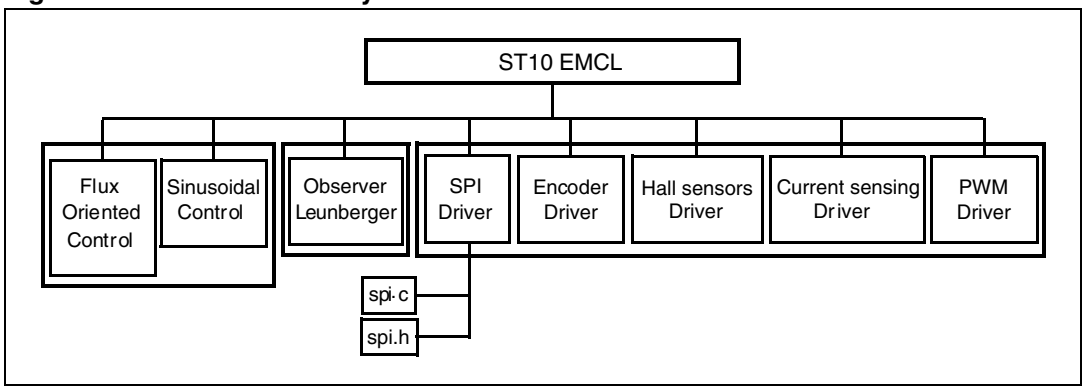
1 Functions set overview

The SPI_FS is a set of functions included in ST10 electric motor control library (see *Figure 1*). It uses the ST10 peripheral SSC configured like SPI interface to allow the full duplex communication with MP49 (slave) and to set a specific MP49 parameters configuration or diagnosis requests, see *Table 2*.

Figure 1. ST10 EMC library structure



The communication between the CPU board and the motor power board is based on SPI interface with a chip select (4 signals in total).

The exchanged data set some parameters and the command to read the status of the motor power board. The configuration command allows to choose the shape of fault pin output signal. Another subset of commands allows to send diagnosis requests to read the status of the inverter driver and of the powerMOS.

2 MP49 to CPU board communication overview

The MP49 motor power board communicates with the CPU board using an SPI interface and using a fault signal to report to the CPU faults as soon as they are detected.

The MP49 requires only to be configured after reset and the CPU does not need any action after initialization as long as the fault pin is not active.

2.1 SPI interface

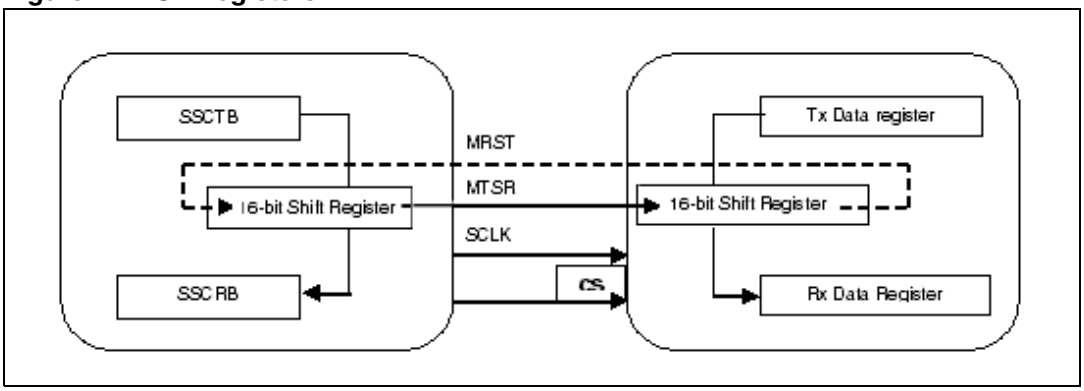
The SPI interface provides a full-duplex, synchronous serial communication between microcontrollers and peripherals. It is based upon a Master-Slave protocol where the master is the device that drives the serial clock signal (SCLK), used to synchronize the communication.

The SPI bus consists of four wires, Serial Clock signal (SCLK), Master Transmit / Slave Receive (MTSR), Master Receive / Slave Transmit (MRST), and Chip Select (CS), which carry information between the devices connected to the bus (see *Figure 2*).

Table 1. SPI master signal description

Name	Direction	Description
MTSR	Output	**SPI Serial Data Output.** Serial data output from the SPI Master to a SPI slave.
MRST	Input	**SPI Serial Data Input.** Serial data input from a SPI slave to the SPI Master.
SCLK	Output	SPI Serial Clock. Normally high, and the correct clock pulse number is sixteen.
CS	Output	**SPI Slave Selects.** Normally high, this input signal starts the communication when it is forced low (for selecting the MP49 board use **pin P2.7**).

Figure 2. SPI registers



The SCLK control line is driven by the SPI Master and regulates the flow of data bits, so that data is shifted on falling edge of SCLK and is sampled on the opposite edge when the data is stable.

This input signal to the MP49 is normally high and the correct clock pulse number is sixteen with a maximum clock frequency of **4MHz**. The master may transmit data at a variety of baud rates.

Note: SPI messages shall be separated by a wait time of 5us minimum. This shall be guaranteed by CPU software.

2.2 SPI diagnostic

The MP49 circuitry includes SPI diagnostic circuitry. The CPU must follow the commands defined in the library. In case of improper command, a fault reporting a SPI diagnostic will be generated.

2.2.1 Fault detection interface

The fault pin from the MP49 board is activated (low level) as soon as at least 1 fault condition occurs.

The CPU then can use status read commands to read the status registers to diagnose the system.

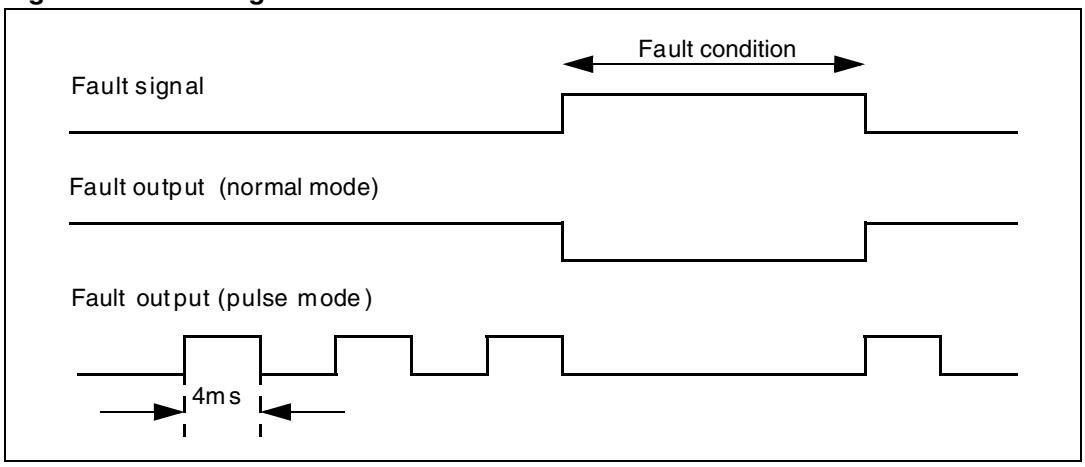
The fault pin is released after the CPU has read the register showing the fault and when there is no more fault condition (continuous hardware detection).

The detected faults are Motor Pre-Driver diagnosis, Thermal Detection, PowerMOS short circuit, Current Regulator diagnosis, LCHG pin diagnosis and SPI communication diagnosis.

When there is no fault, the signal on the fault pin can be configured to be a static high signal or to be a 4ms period signal (pulses).

By default, the fault pin is set to be a 4ms pulse signal (see *Figure 3*).

Figure 3. Fault signal



3 API specification

The following APIs allow easy access to set a specific configuration or read the status of the motor power board.

The use of these functions eliminates the need to access directly ST10 registers.

Available functions:

- SetCom()
- ShortMotorDriver()
- LowVoltPreDriver()
- SPINGFailDetect()

described in the following.

The communication between the ST10 microcontroller and the MP49 power board through the SPI interface uses a set of four commands, listed in *Table 2* , to set a specific MP49 parameters configuration or a diagnosis request.

Table 2. SPI commands

Item	Definition
COMMAND	configuration of a parameters set
DIAG_READ1	Motor Driver Short Diagnosis
DIAG_READ2	Pre Driver VGS Low Voltage
DIAG_READ3	SPI Diagnosis

The command to set the MP49 board configuration sends back the echo of the configuration. Note that when the diagnosis requests are read from the microcontroller, each flag of the Tx data register from MP49 board is cleared.

In the following the functions that allow to set a specific configuration, read the echo from MP49 power board, and send a specific diagnosis request are listed

(see file spi.c in the sw library).

3.1 Function definition for motor power board configuration

In the following the function for setting a specific MP49 parameters configuration is specified (see file spi.c in the sw library).

3.1.1 SetCom

Prototype definition:

UINT16 SetCom(UINT16 command)

Parameters:

Parameter	Description
command	Command to set the MP49 power board. Define *command* value using OR-ing of constants defined in spi.h

Return value:

Return value	Description / meaning
OK	no errors
FAIL_REGWRITE_MP49	read data is different from sent one
FAIL_MP49	wrong keyword

Description:

Set the command to MP49 and check the echo from MP49.

Example:

SetCom(COMMAND | PSA_ON | FAULT_OUT_NORMAL)

See predefined constants in spi.h.

3.2 Function definitions for the motor power board diagnosis

In the following the functions for the diagnosis are specified, (see file spi.c).

3.2.1 ShortMotorDriver

Prototype definition:

UINT16 ShortMotorDriver(struct DIAG1*p_ diag_1)

Parameters:

Parameter	Description
p_diag_1	pointer to diagnosis structure

Return value:

Return value	Description/meaning
OK	no short
FAIL_MP49_DIAG	found short
FAIL_MP49	wrong keyword

Description:

Set the command to MP49 power board and read the status of short diagnosis of the motor driver.

3.2.2 LowVoltPreDriver

Prototype definition:

UINT16 LowVoltPreDriver(struct DIAG2* p_diag_2)

Parameters:

Parameter	Description
p_diag_2	pointer to diagnosis structure

Return value:

Return value	Description/meaning
OK	normal
FAIL_MP49_DIAG	found fail
FAIL_MP49	wrong keyword

Description:

Set the command to MP49 power board and read the status of low voltage diagnosis of the pre-driver.

3.2.3 SPINGFailDetect

Prototype definition:

UINT16 SPINGFailDetect(struct DIAG3* p_diag_3)

Parameters:

Parameter	Description
p_diag_3	pointer to the diagnosis structure

Return value:

Return value	Description/meaning
OK	normal
FAIL_MP49_DIAG_SPING	found fail
FAIL_MP49	wrong keyword

Description:

Set the command to MP49 power board and read the status of diagnosis of SPI.

3.3 Type definitions

There are three different structures, here defined, to store the status of diagnosis for each request command, used in functions of diagnosis (e.g. DIAG1 for short diagnosis of the MOTOR DRIVER).

3.3.1 DIAG1

Table 3. DIAG1 structure

Type:	struct
Description:	Each field of the structure stores short diagnosis on **motor driver:** WL,WH,VL,VH,UL,UH. See the file spi.h

3.3.2 DIAG2

Table 4. DIAG2 structure

Type:	struct
Description:	Each field of the structure stores low voltage diagnosis on **pre driver VGS:** WLV,WHV,VLV,VHV,ULV,UHV. See the file spi.h.

3.3.3 DIAG3

Table 5. DIAG3 structure

Type:	struct
Description:	The structure stores the **Fail**: SPING See the file spi.h.

Appendix A

The following table is showing the commands available to configure the MP49 power board.

Configuration command

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	X	X	0	0	0	0	1	FAULT	0	0

Name	Bits	Value	Description
Command field	15 to 10	must be “000001”	Command key word
dummy bits	9, 8	x	Dummy bits The value of those bits is ignored.
reserved bit field1	7,6,5,4	0000	Reserved The software must always write those bits as 0
reserved bit field2	3	1	Reserved The software must always write those bits as 1
FAULT	2	0 1	FAULT pin signal selection pulse mode (default value after reset) level mode (no-fault = high-level; fault = low-level)
reserved bit field3	1,0	00	Reserved The software must always write those bits as 0

Motor driver short diagnosis read command

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	0	x	x	x	x	x	x	x	x	x	x

Name	Bits	Value	Description
Command field	15 to 10	must be “001000”	Read DIAG_READ1 key word On the next command, the MP49 board will send the Motor driver short register on the SPI.
dummy bits	9 to 0	x	Dummy bits The value of those bits is ignored.

Predriver’s low voltage diagnosis read command

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	0	X	X	x	x	x	x	x	x	x	x

Name	Bits	Value	Description
Command field	15 to 10	must be “010000”	Read DIAG_READ2 key word On the next command, the MP49 board will send the Predriver’s low voltage register on the SPI.
dummy bits	9 to 0	x	Dummy bits The value of those bits is ignored.

SPI communication diagnosis read command

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	0	X	X	x	x	x	x	x	x	x	x

Name	Bits	Value	Description
Command field	15 to 10	must be “011000”	Read DIAG_READ3 key word On the next command, the MP49 board will send the SPI communication register on the SPI.
dummy bits	9 to 0	x	Dummy bits The value of those bits is ignored.

The following table is showing the meaning of the status registers of the MP49 power board.

Motor driver short diagnostic

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
x	0	0	1	0	0	0	x	UH	UL	VH	VL	WH	WL	0	0

Name	Bits	Value	Description
Command echo field	14 to 9	001000	Read DIAG_READ1 command key word this bit field is echoing the command field of the read DIAG_READ1 command
UH	7		PowerMOS UH short diagnostic 0 = normal 1 = short
UL	6		PowerMOS UL short diagnostic 0 = normal 1 = short
VH	5		PowerMOS VH short diagnostic 0 = normal 1 = short

Name	Bits	Value	Description
VL	4		PowerMOS VL short diagnostic 0 = normal 1 = short
WH	3		PowerMOS WH short diagnostic 0 = normal 1 = short
WL	2		PowerMOS WL short diagnostic 0 = normal 1 = short
dummy bits	1,0		Reserved Those bits are always 0.

PREdriver low voltage diagnostic

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
x	0	1	1	0	0	0	x	UHV	ULV	VHV	VLV	WHV	WLV	0	0

Name	Bits	Value	Description
Command echo field	14 to 9	010000	Read DIAG_READ2 command key word this bit field is echoing the command field of the read DIAG_READ2 command
UHV	7		UHV predriver short diagnostic 0 = normal 1 = under voltage
ULV	6		ULV short diagnostic 0 = normal 1 = under voltage
VHV	5		VHV short diagnostic 0 = normal 1 = under voltage
VLV	4		VLV short diagnostic 0 = normal 1 = under voltage
WHV	3		WHV short diagnostic 0 = normal 1 = under voltage
WLV	2		WLV short diagnostic 0 = normal 1 = under voltage
dummy bits	1,0		Reserved Those bits are always 0.

SPI communication diagnostic

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
x	0	1	1	0	0	0	x	x	x	SPING	x	x	x	x	0

Name	Bits	Value	Description
Command echo field	14 to 9	011000	Read DIAG_READ3 command key word this bit field is echoing the command field of the read status3 command
dummy bits	8,7,6		Reserved Those bits should be ignored (either 0 or 1).
SPING	5		SPI diagnostic 0 = normal 1 = SPI error (non valid command in command bit field or less than 16 clock periods in an SPI frame.
dummy bits	4,3,2,1		Reserved Those bits should be ignored (either 0 or 1).
dummy bits	0		Reserved This bit is always 0.

4 Revision history

Table 6. Document revision history

Date	Revision	Changes
09-Mar-2007	1	Initial release.

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